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(54) **PRESSURE REGULATOR BAFFLE SEAT WITH RADIAL FLOW PATHS**

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This patent is subject to a terminal disclaimer.

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(52) **U.S. Cl.** **137/508**; 123/459
(58) **Field of Search** 137/508; 123/459

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Primary Examiner—Stephen M. Hepperle

(57) **ABSTRACT**

A flow-through pressure regulator includes a housing having an inlet and an outlet offset along a longitudinal axis. The housing is separated by a divider into a first chamber and a second chamber. The divider has a passage that communicates the first chamber with the second chamber. The passage includes a first section extending along the longitudinal axis and a second section extending transverse to the longitudinal axis. A closure member permits or inhibits flow through the passage.

20 Claims, 5 Drawing Sheets

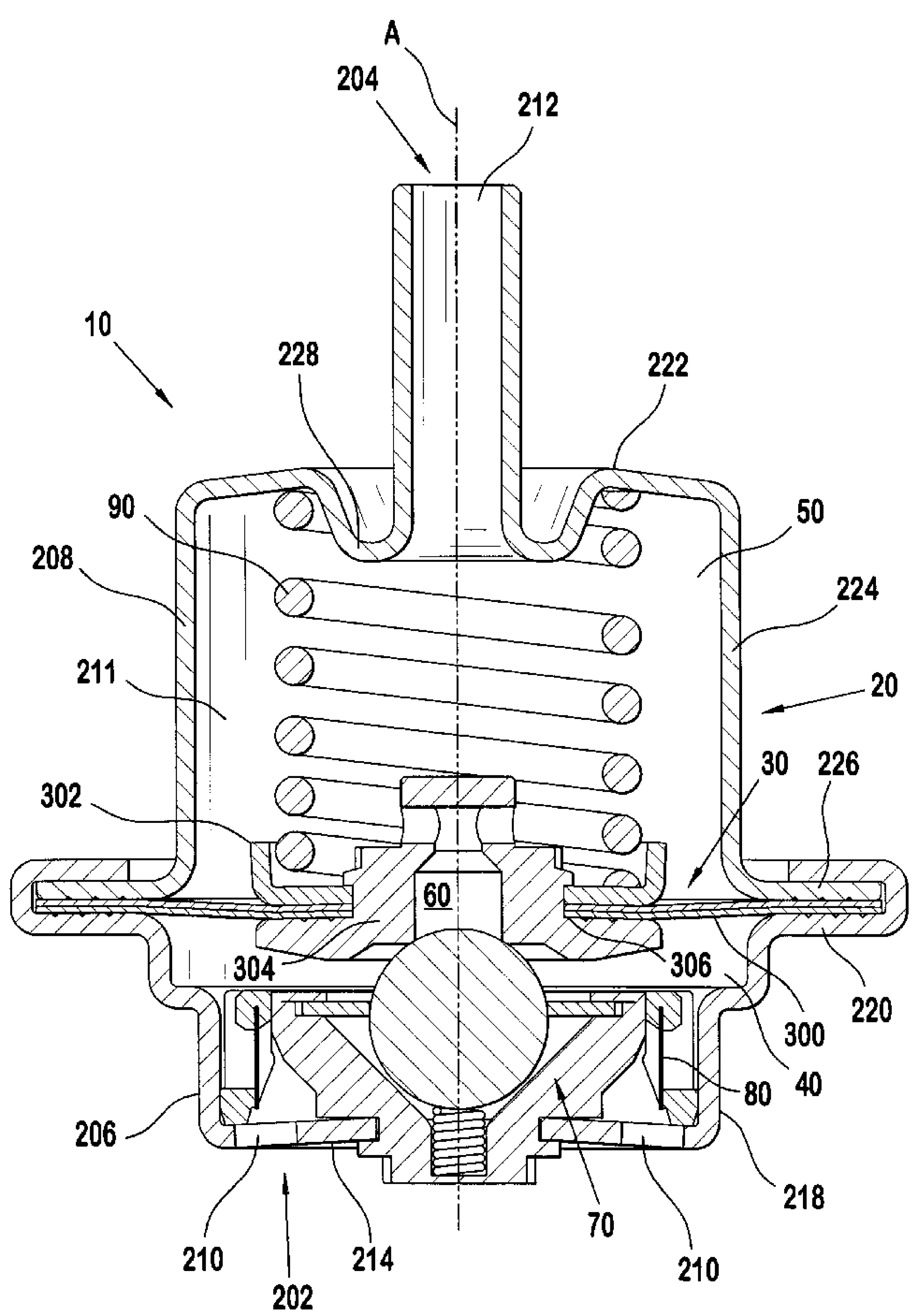


FIG. 1

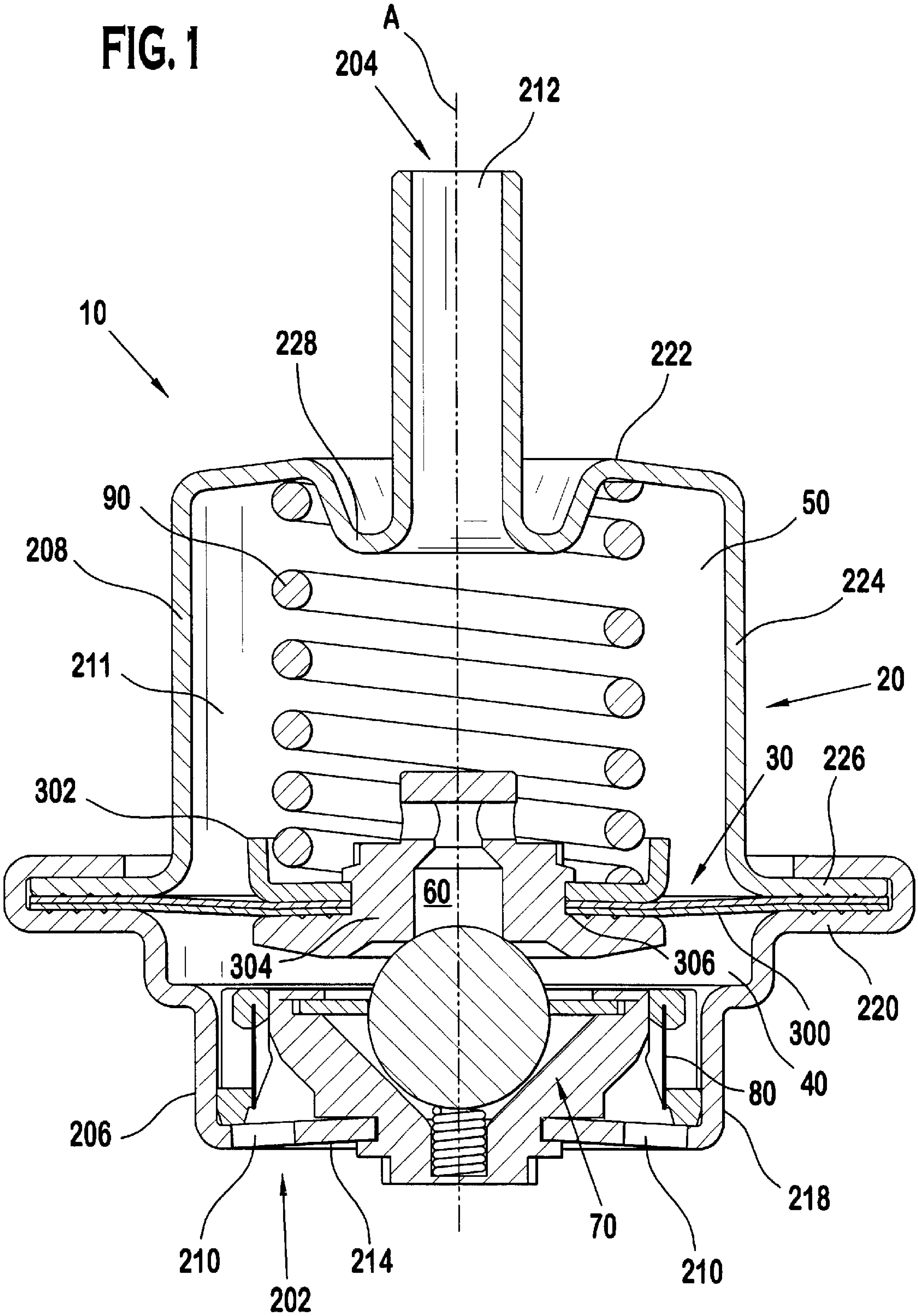

A
204
212
10
228
222
90
50
208
224
211
20
30
226
302
60
304
306
300
220
80
40
206
218
70
210
214
210
202

FIG. 2

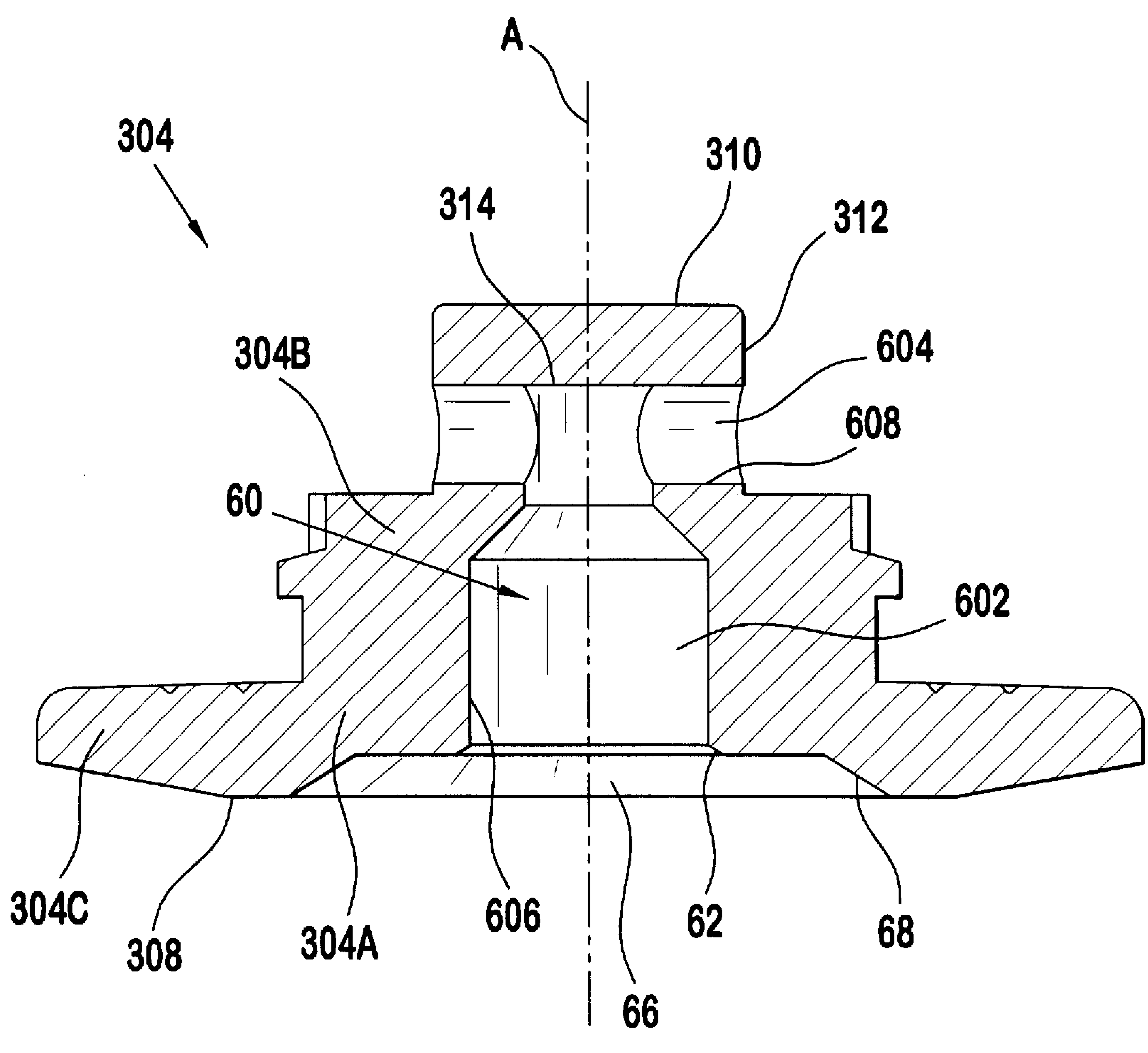


FIG. 3

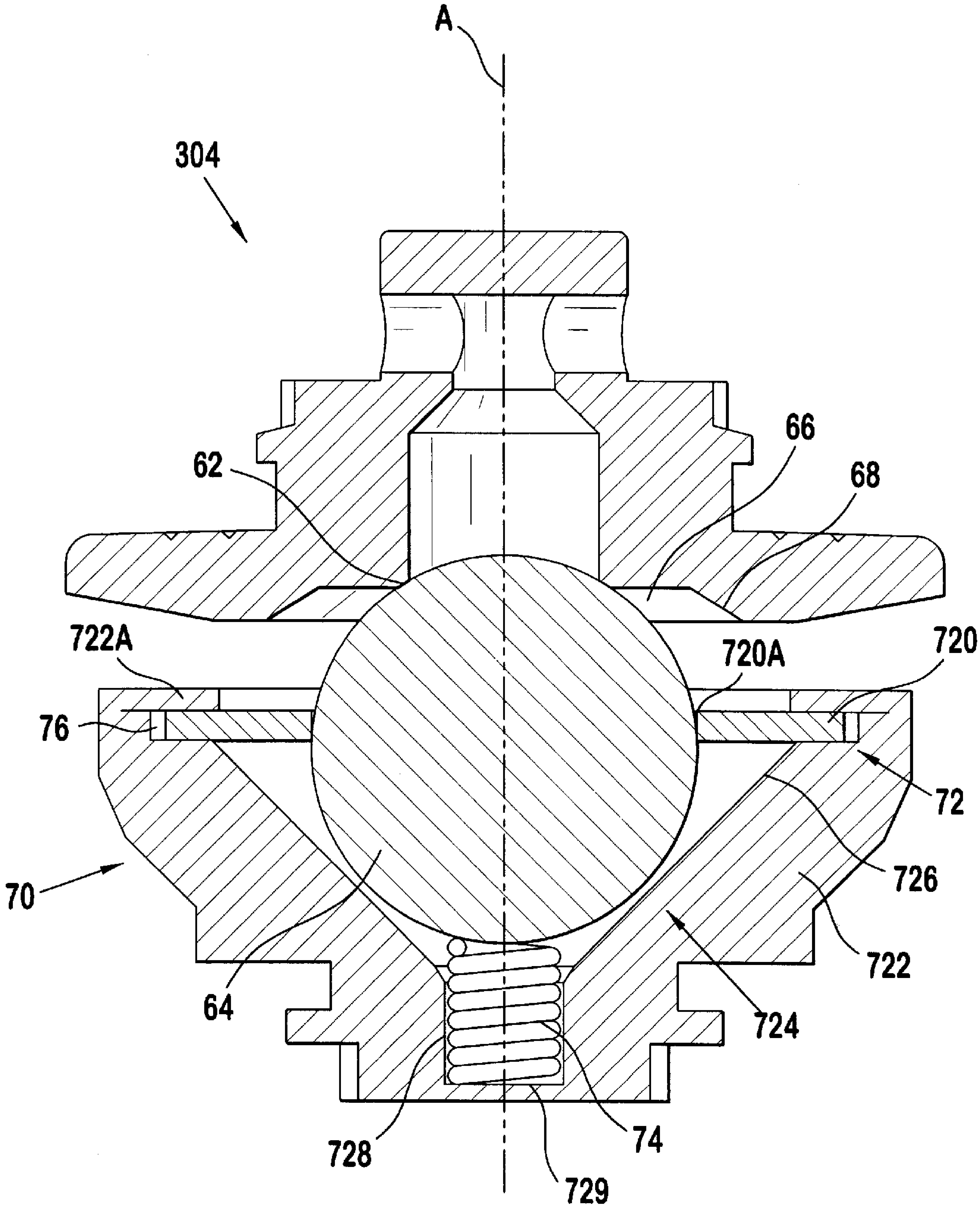


FIG. 4

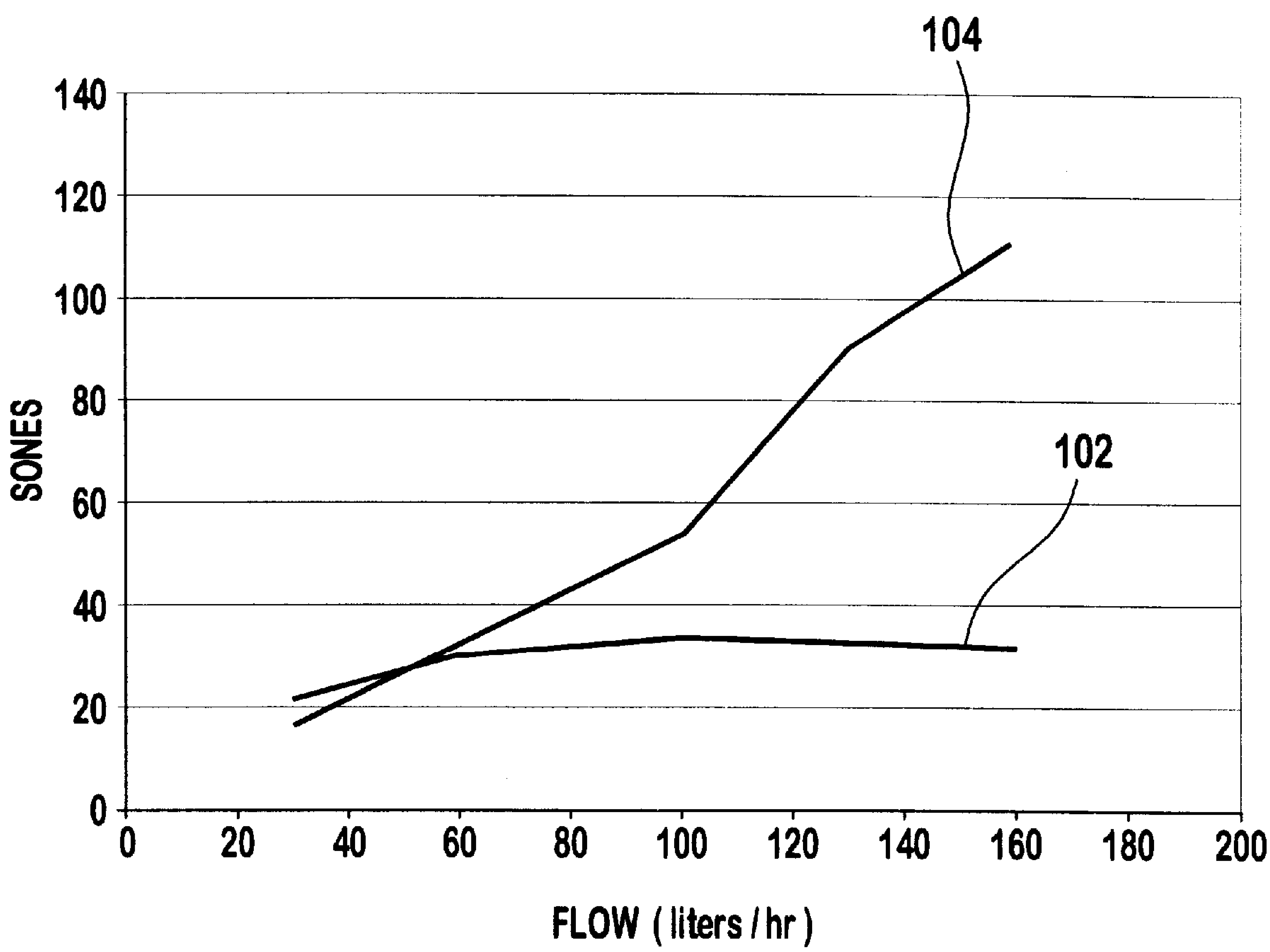

104
102
140
120
100
80
60
40
20
0
SONES
0
20
40
60
80
100
120
140
160
180
200
FLOW (liters / hr)

FIG. 5
PRIOR ART

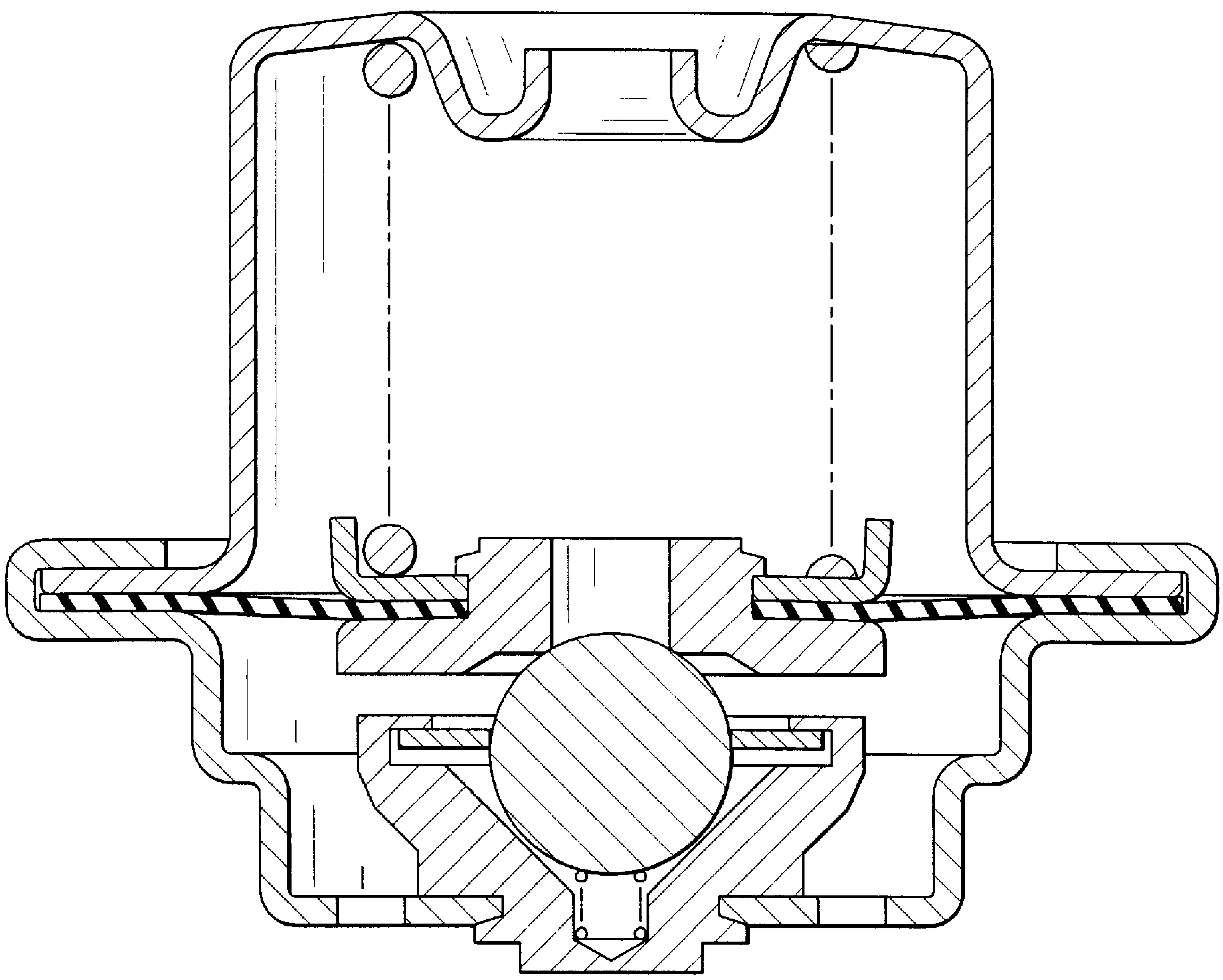
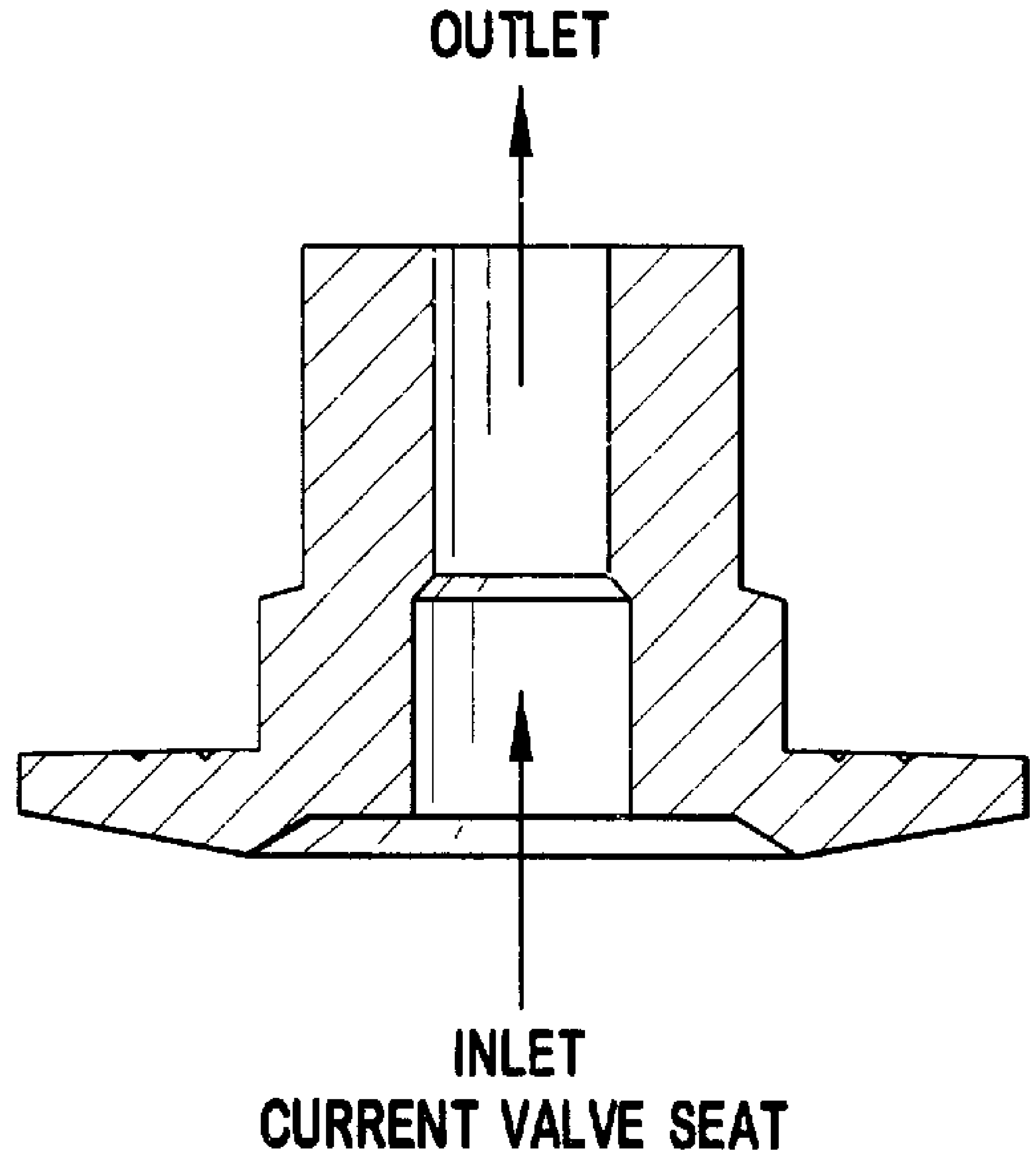


FIG. 6
PRIOR ART



PRESSURE REGULATOR BAFFLE SEAT WITH RADIAL FLOW PATHS

FIELD OF THE INVENTION

This invention relates to a baffle seat for a pressure regulator for automotive fuel systems, and more particularly to a baffle seat having a geometry which reduces the noise associated with high fuel flow rates through the baffle seat.

BACKGROUND OF THE INVENTION

Most modern automotive fuel systems utilize fuel injectors to deliver fuel to the engine cylinders for combustion. The fuel injectors are mounted on a fuel rail to which fuel is supplied by a pump. The pressure at which the fuel is supplied to the fuel rail must be metered to ensure the proper operation of the fuel injectors. Metering is carried out using pressure regulators which control the pressure of the fuel in the system at all engine r.p.m. levels.

Known pressure regulators, as shown in FIG. **5**, employ a spring biased valve seat with a longitudinal flow passage. A detailed view of a known valve seat is shown in FIG. **6**. The valve seat is biased to a closed position to prevent the flow of fuel through the pressure regulator at low fuel pressures. As fuel pressure builds in the system, the pressure against the valve seat overcomes the biasing force of the spring, allowing fuel to flow through the valve seat, thereby controlling the fuel pressure in the system.

Fuel flow rate, measured in liters per hour, through known pressure regulators tends to be low at high engine speed; measured in revolutions per minute, as large quantities of fuel are consumed in the combustion process. And at low engine speeds, less fuel is consumed in combustion and flow rates through the pressure regulators are high. These high fuel flow rates through known pressure regulator valve seats produce unacceptably high noise levels. A valve seat is needed that maintains flow noise within acceptable levels, even at high fuel flow rates.

SUMMARY OF THE INVENTION

The present invention provides a flow-through pressure regulator which maintains a substantially constant noise output from low fuel flow rates to high fuel flow rates. The flow-through pressure regulator includes a housing having an inlet and an outlet offset along a longitudinal axis. The housing is separated by a divider into a first chamber and a second chamber. The divider has a passage that communicates the first chamber with the second chamber. The passage includes a first section extending along the longitudinal axis and a second section extending transverse to the longitudinal axis. A closure member permits or inhibits flow through the passage.

The divider can include a baffle seat that is suspended by the divider in the housing and provides the passage. The baffle seat has a first seat portion and a second seat portion disposed along the longitudinal axis on opposite sides of the divider such that the first seat portion is disposed the first chamber and the second seat portion is disposed in the second chamber. The first section of the passage extends along the longitudinal axis through the first portion and into the second portion of the seat. The second section of the passage extends transverse to the longitudinal axis in the second portion of the seat.

The baffle seat can comprise a first surface disposed in the first chamber, a second surface disposed in the second chamber, and a side surface disposed between the first surface and the second surface. The first section of the passage communicates with the first surface and the second section communicates with the side surface. The first section has a first wall extending from the first surface of the seat to an end wall within the second portion of the seat, and the second section has a second wall extending from the first wall to the side surface. The second wall extends from the first wall to diametrically opposed locations on the side surface, and intersects the first wall proximate the end wall.

In a preferred embodiment, the divider is a diaphragm, and a first biasing element is located in the second chamber. The closure member includes a ball disposed in a retainer. The housing includes a first cup-shaped member and a second cup-shaped member. In a preferred embodiment, the flow-through pressure regulator of the present invention has a sound rating in Sones that remains substantially constant from a low fuel flow rate to a high fuel flow rate.

The present invention also provides a low noise baffle seat for a flow-through regulator. The baffle seat has an exit geometry which reduces output noise levels at high fuel flow rates. The baffle seat includes a first seat portion having a first surface disposed about a central axis, a second seat portion having a second surface offset from the first surface along the central axis, a side surface disposed between the first surface and the second surface and a passage extending from the first surface through the first portion and the second portion to the side surface. The passage has a first section and a second section. The first section of the passage extends along the central axis in both the first portion and the second portion of the baffle seat. The second section of the passage extends transverse to the longitudinal axis in the second portion of the baffle seat. The first section communicates with the first surface and the second section communicates with the side surface.

The present invention also provides a method of stabilizing noise generation in a flow-through regulator. The flow-through regulator includes a housing with an inlet and an outlet offset along a longitudinal axis, a divider separating the housing into a first chamber and a second chamber, a passage through the divider that provides communication between the first chamber and the second chamber, and a closure member that permits or inhibits flow through the passage. The method is achieved by providing the passage with a first section extending along the longitudinal axis and a second section extending transverse to the longitudinal axis, and communicating the first section with the first chamber and the second section with the second chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate presently preferred embodiments of the invention and, together with the general description given above and the detailed description given below, serve to explain features of the invention.

FIG. **1** illustrates a flow-through regulator according to the present invention.

FIG. **2** illustrates the baffle seat of the flow-through regulator shown in FIG. **1**.

FIG. **3** illustrates a detailed view of the baffle seat of the present invention and a closure member.

FIG. **4** is a graph illustrating the relationship between noise and flow rate.

FIG. **5** illustrates a prior art pressure regulator.

FIG. **6** illustrates a detailed view of a prior art valve seat.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** illustrates a flow-through pressure regulator **10** according to the present invention. The flow-through pressure regulator **10** includes a housing **20**. The housing **20** is separated by a divider **30** into a first chamber **40** and a second chamber **50**. The divider **30** has a passage **60** that communicates the first chamber **40** with the second chamber **50**. A closure member **70** permits or inhibits flow through the passage **60**. A filter **80** is disposed in the flow path of the housing **20**. The housing **20**, has an inlet **202** and an outlet **204** offset along a longitudinal axis A. The housing **20** can include a first cup-shaped member **206** and a second cup-shaped member **208** that are crimped together to form a unitary housing **20** with a hollow interior **211**. Although the unitary housing is formed by two joined members, it is to be understood that the unitary housing could be formed with multiple members integrated together or, alternatively, a monolithic member. The inlet **202** of the housing **20** is located in the first cup-shaped member **206**, and the outlet **204** of the housing **20** is located in the second cup-shaped member **208**. The inlet **202** can be a plurality of apertures **210** located in the first cup-shaped member **206**. The outlet **204** can be a port **212** disposed in the second cup-shaped member **208**.

The first cup-shaped member **206** can include a first base **214**, a first lateral wall **218** extending in a first direction along the longitudinal axis A from the first base **214**, and a first flange **220** extending from the first lateral wall **218** in a direction substantially transverse to the longitudinal axis A. The second cup-shaped member **208** can include a second base **222**, a second lateral wall **224** extending in a second direction along the longitudinal axis A from the second base **222**, and a second flange **226** extending from the second lateral wall **224** in a direction substantially transverse to the longitudinal axis A. A divider **30**, which can be a diaphragm **300**, is secured between the first flange **220** and the second flange **226** to separate the first chamber **40** and the second chamber **50**. The first flange **220** can be rolled over the circumferential edge of the second flange **226** and can be crimped to the second flange **226** to form the unitary housing **20**.

A first biasing element **90** which is preferably a spring, is located in the second chamber **50**. The first biasing element **90** engages a locator **228** on the base **222** of the second cup-shaped member **208** and biases the diaphragm **300** toward the base **214** of the first-cup shaped member **206**. The first biasing element **90** biases the diaphragm **300** of the regulator **10** at a predetermined force, which relates to the pressure desired for the regulator **10**. The base **222** of the second cup-shaped member **208** has a dimpled center portion that provides the outlet port **212** in addition to the locator **228**. The first end of the spring **90** is secured on the locator **228**, while a second end of the spring **90** can be supported by a retainer **302**, which is secured to a baffle seat **304** mounted in a central aperture **306** in the diaphragm **300**.

FIG. **2** shows a preferred embodiment of the baffle seat **304**. The baffle seat **304** is suspended by the divider **30** in the housing **20** (FIG. **1**) to provide the passage **60**, having a first section **602** and a second section **604**. The baffle seat **304** has a first seat portion **304**A and a second seat portion **304**B disposed along the longitudinal axis A. The first seat portion **304**A is disposed in the first chamber **40** and the second seat portion **304**B is disposed in the second chamber **50** (FIG. **1**). The first section **602** of the passage **60** extends along the longitudinal axis A in both the first portion **304**A and the second portion **304**B of the baffle seat **304**. The second section **604** of the passage **60** extends transverse to the longitudinal axis A in the second portion **304**B of the baffle seat **304**.

The baffle seat **304** preferably has a first surface **308** disposed in the first chamber **40** (FIG. **1**), a second surface **310** disposed in the second chamber **50** (FIG. **1**), and a side surface **312** extending between the first surface **308** and the second surface **310**. The first section **602** of the passage **60** communicates with the first surface **308** and the second section **604** of the passage **60** communicates with the side surface **312**. The first section **602** has a first wall **606** extending from the first surface **308** to an end wall **314** within the second portion **304**B, and the second section **604** has a second wall **608** extending from the first wall **606** to the side surface **312**. The second wall **608** can extend in opposite directions from the first wall **606** to locations on the side surface **312**, and intersects the first wall **606** proximate the end wall **314**. Of course, the second wall **608** can extend in a single radial direction from the first wall **606**.

It should be noted that the baffle seat **304** of the present invention can be manufactured as a monolithic valve seat or, alternatively, as separate components that can be assembled. The baffle seat **304** can be used to retrofit existing valve seats having only a longitudinal flow path. For example, the separate components can comprise a cap providing an end wall **314** and a second section **604** of the passage **60**.

At an end of the passage **60** opposite the end wall **314** is a seating surface **62** on which the closure member **70**, which can be a valve actuator ball **64**, seats. FIG. **3** shows the ball **64** seated on the valve surface **62**. This surface **62** begins at an inner edge of a pocket **66** which has its side walls **68** converging toward the axis A of the baffle seat **304**. This end of the baffle seat **304** opens into the first chamber **40** (FIG. **1**). In the manufacturing of the baffle seat **304**, the seating surface **62** is finished to assure a smooth sealing surface for the ball **64**.

FIG. **3** shows that the closure member **70** can include a ball **64** disposed in a retainer **72**. The retainer **72** is located in the first chamber **40** (FIG. **1**), and has a flat annulus **720** secured to a valve actuator housing **722**. The housing **722** can have an internal funnel **724** that includes a conical portion **726** confronting the flat annulus **720** and a cylindrical portion **728** occluded by an end wall **729**. The conical portion **726** of the funnel **724** can support the ball **64**. The cylindrical portion **728** of the funnel **724** supports a spring **74** that biases the ball **64** toward the divider **30** (FIG. **1**). The conical portion **726** is sized so as to not interfere with the movement of the ball **64**. The ball **64** is retained by the flat annulus **720** on a ball surface opposite the spring **74**. The annulus **720** has a central aperture **720**A that is somewhat smaller than the diameter of the ball **64**. The aperture **720**A is finished to prevent a rough surface from contacting the ball **64**. At the wide end of the funnel **724** there is formed a pocket **76**. The annulus **720**, which is located above the major diameter of the ball or its horizontal axis, is located in the pocket **76** against the inside of the upper edge of the valve actuator housing **722**. The annulus **720** has an outside diameter which is smaller than the diameter of the pocket **76** of the housing **722** and can be retained against separation from the housing **722** by crimping of the upper edge **722**A of the valve actuator housing **722** over the annulus **720**. The annulus **720** is not held tightly in the pocket **76** at the end of the funnel **724**, but is free to move both axially and radially in the pocket **76**.

One method of assembling the fuel regulator **10** is by first securing the valve actuator housing **722** to the first cup-shaped member **206**. The small bias spring **74** is placed in the bore **728**. The ball **64** is then located in the conical portion **726** of the funnel **724** formed in the valve actuator housing **722**. Next, the annulus **720** is placed in the pocket **76** on the upper edge of the housing **722** and the edges **722A** of the housing **722** are crimped over to retain the annulus **720** in the pocket **76**. The baffle seat **304** is located and secured in the central aperture **306** of the diaphragm **300** between a flange **304C** of the baffle seat member **304** and the spring retainer **302**. This completed diaphragm is located on the upper flange surface **220** of the first cup-shaped member **206**. The bias spring **90** is positioned in the spring retainer **302** and the second cup-shaped member **208** is then placed over the spring **90** and located on the diaphragm **300**. The flange **220** of the first cup-shaped member **206** is crimped down to secure the second cup-shaped member **208**. The first and second cup-shaped members **206,208** and the diaphragm **300** form a unitary member. The pressure at which the fuel is maintained is determined by the spring force of the bias spring **90**.

The operation of the flow-through pressure regulator will now be described. The bias spring **90** acts through the retainer **302** to bias the divider **30** toward the base **214** of the first cup-shaped member **206**. The spring **74** functions to bias the ball **64** against the seating surface **62** in the baffle seat member **304**. When the ball **64** is seated against surface **62**, the baffle seat is in a closed position and no fuel can pass through the regulator.

Fuel enters the regulator **10** through apertures **210** and exerts pressure on the divider **30**. When the pressure of the fuel is greater than the force exerted by the large bias spring **90**, the diaphragm **300** moves in an axial direction and the ball **64** leaves the seating surface **62** of the baffle seat member **304**. Fuel can then flow through the regulator **10**. The fuel enters the first section **602** of the passage **60**, then passes into the second section **604**. In the second section **604**, the fuel is diverted transversely to the longitudinal axis A, and leaves the baffle seat **304** through the side surface **312**. Experimentation has shown that this exit geometry on the baffle seat provides a substantially constant noise output level from a low fuel flow rate to a high fuel flow rate.

As the fuel pressure is reduced, the force of the large bias spring **90** overcomes the fuel pressure and returns the baffle seat member **304** to seated engagement with the ball **64**, thus closing the passage **60** in the baffle seat member **304**.

As shown in FIG. **4**, curve **102** shows that noise is generally consistent over a range of flow rates according to the present invention. In contrast, curve **104** shows that noise increases substantially as flow increases through conventional regulators.

While the invention has been disclosed with reference to certain preferred embodiments, numerous modifications, alterations, and changes to the described embodiments are possible without departing from the sphere and scope of the invention, as defined in the appended claims and their equivalents thereof. Accordingly, it is intended that the invention not be limited to the described embodiments, but that it have the full scope defined by the language of the following claims.

What we claim is:

1. A flow-through pressure regulator, comprising:

a housing having an inlet and an outlet offset along a longitudinal axis;

a divider separating the housing into a first chamber and a second chamber, the divider having a passage that communicates the first chamber with the second chamber, the passage including a first section extending along the longitudinal axis and a second section extending transverse to the longitudinal axis; and

a closure member that permits or inhibits flow through the passage.

2. The flow-through regulator of claim **1**, wherein the divider comprises a seat, the seat being suspended by the divider in the housing to provide the passage, the seat having a first seat portion and a second seat portion disposed along the longitudinal axis, the first seat portion being disposed in the first chamber, a second seat portion being disposed in the second chamber, the first section of the passage extending along the longitudinal axis in both the first portion and the second portion of the seat, and the second section of the passage extending transverse to the longitudinal axis in the second portion of the seat.

3. The flow-through regulator of claim **2**, wherein the seat comprises a first surface disposed in the first chamber, a second surface disposed in the second chamber, and a side surface disposed between the first surface and the second surface.

4. The flow-through regulator of claim **3**, wherein the first section communicates with the first surface and the second section communicates with the side surface.

5. The flow-through regulator of claim **4**, wherein the first section comprises a first wall extending from the first surface to an end wall within the second portion, and wherein the second section comprises a second wall extending from the first wall to the side surface.

6. The flow-through regulator of claim **5**, wherein the second wall extends from the first wall to diametrically opposed locations on the side surface, and intersects the first wall proximate the end wall.

7. The flow-through regulator of claim **1**, wherein the divider comprises a diaphragm.

8. The flow-through regulator of claim **7**, and further comprising:

a first biasing element located in the second chamber, the first biasing element engaging a locator on an end of the second cup-shaped member and biasing the diaphragm toward an end of the first cup-shaped member.

9. The flow-through regulator of claim **1**, wherein the closure member comprises a ball disposed in a retainer, the retainer being located in the first chamber, and having a flat annulus secured to a housing, the housing having an internal funnel, the internal funnel including a conical portion confronting the flat annulus and a cylindrical portion with an end wall, the conical portion of the funnel supporting the ball, and the cylindrical portion of the funnel supporting a spring that biases the ball toward the divider.

10. The flow-through regulator of claim **1**, wherein the housing comprises a first cup-shaped member and a second cup-shaped member, the first cup-shaped member having a first base, a first lateral wall extending in a first direction along the longitudinal axis from the first base, and a first flange extending from the first lateral wall in a direction substantially transverse to the longitudinal axis, the second cup-shaped member having a second base, a second lateral wall extending in a second direction along the longitudinal axis from the second base, and a second flange extending from the second lateral wall in a direction substantially transverse to the longitudinal axis, the first flange and the second flange being secured together to provide a unitary housing.

11. The flow-through regulator of claim **10**, wherein the divider comprises a diaphragm secured between the first flange and the second flange to provide the first chamber and the second chamber.

12. The flow-through regulator of claim **1**, wherein the flow-through pressure regulator emits sound at a sound rating in Sones that remains substantially constant from a low fuel flow rate to high fuel flow rate.

13. A seat for a flow-through regulator, the seat comprising:

a first seat portion having a first surface disposed about a central axis;

a second seat portion having a second surface offset from the first surface along the central axis;

a side surface disposed between the first surface and the second surface; and

a passage extending from the first surface through the first portion and the second portion to the side surface, the passage having a first section and a second section, the first section of the passage extending along the central axis in both the first portion and the second portion of the seat, the second section of the passage extending transverse to the central axis in the second portion of the seat, the first section communicating with the first surface and the second section communicating with the side surface.

14. The seat of claim **13**, wherein the first section comprises a first wall extending from the first surface to an end wall within the second portion, and wherein the second section comprises a second wall extending from the first wall to the side surface.

15. The seat of claim **14**, wherein the second wall extends from the first wall to diametrically opposed locations on the side surface, and intersects the first wall proximate the end wall.

16. A method of stabilizing noise generation in a flow-through regulator, wherein the flow-through regulator includes a housing with an inlet and an outlet offset along a longitudinal axis, a divider separating the housing into a first chamber and a second chamber, the divider including a passage that provides communication between the first chamber and the second chamber, and a closure member that permits or inhibits flow through the passage, the method comprising:

providing the passage with a first section extending along the longitudinal axis and a second section extending transverse to the longitudinal axis; and

communicating the first section with the first chamber and the second section with the second chamber.

17. The method of claim **16**, further comprising:

providing the first section with a first wall;

providing the second section with a second wall; and

extending the second wall through the first wall to diametrically opposed locations.

18. The method of claim **17**, further comprising:

suspending a seat with the divider in the housing to provide the passage, the seat having a first seat portion and a second seat portion disposed along the longitudinal axis, the first seat portion being disposed in the first chamber, a second seat portion being disposed in the second chamber, the first section of the passage extending along the longitudinal axis in both the first portion and the second portion of the seat, and the second section of the passage extending transverse to the longitudinal axis in the second portion of the seat.

19. The method of claim **18**, wherein the seat comprises a first surface disposed in the first chamber, a second surface disposed in the second chamber, and a side surface disposed between the first surface and the second surface, and further comprising:

extending the first wall from the first surface to an end wall within the second portion; and extending the second wall from the first wall to the side surface.

20. The method of claim **19**, further comprising:

extending the second wall from the first wall to diametrically opposed locations on the side surface; and

intersecting the first wall with the second wall proximate the end wall.

* * * * *